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MAPPING THE COVERAGE OF NEUROIMAGING RESEARCH

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Abstract

The increasing popularity of neuroimaging studies among the research community in recent decades has also garnered interest from the media. But there is concern that coverage of controversial topics, such as the ability of fMRI to "read minds", has sensationalised the neuroimaging field and led to mounting criticism and skepticism. In order to explore this phenomenon, we mapped the frequency and tone of research and review articles regarding fMRI published in the journals *Science* and *Nature*. We also examined the frequency and tone of the newspaper articles that reported the results of these research articles. The results indicate a distinct trend in the level of interest in neuroimaging studies, the topics of research, and the concomitant criticism over time. It appears that while more sensational research articles generate more media coverage, they also receive more criticism from within the scientific community. The results also provide tentative support for the existence of a classic "hype cycle" that may raise important questions about public perception and the long-term integrity of the neuroimaging field.

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1. Introduction

Over the past decade, the field of neuroimaging has received significant attention in both scientific literature and the popular press.[1] It has captured the public imagination as a way to explore the workings of the human mind and even as a field that can tell us much about the human condition: from why "love hurts" to why some of us are optimists.[2] Indeed recent advances in neuroimaging, largely the result of the increased efficiency and use of functional magnetic resonance imaging (fMRI) technology, have been portrayed as a way to read minds.[3]

Given the intense attention, it is not surprising that the field has also received a good deal of criticism. Numerous commentators have suggested that the results of fMRI studies have been over-interpreted and that correlations between fMRI findings and human cognitive and emotional responses are far from conclusive.[4] As noted by Miller, neuroimaging fMRI studies "may have a power to captivate that reaches beyond their power to explain".[5] Accordingly, there is concern that the field is being inappropriately sensationalised, sparking discussions of more transparent public engagement in the field of neuroscience.[6]

In this paper, we explore the rise of interest in neuroimaging as represented in both the science literature and the popular press. The attention given to fMRI studies provides an opportunity to seek an understanding of the public face of a relatively new technique (fMRI), to speculate about the types of findings that trigger media coverage, and to map the evolution of skepticism. Given the controversial nature of the area of neuroimaging, it is also a chance to investigate how publication trends may help to "sensationalize" the popular representations – such as media reporting – of an emerging field of study.

2. Methods

This work builds on similar analysis done by others, such as Illes et al[7] by looking at the nature and tone of fMRI papers published in *Science* and *Nature* regarding fMRI research. Since *Science* and *Nature* are the highest impact general science journals

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[1] N Logothetis, "What We Can Do and What We Cannot Do with fMRI" (2008) 453 *Nature* 869–878.

[2] R Hotz, "Hard-Wired for Optimism" (9 November 2007) *The Wall Street Journal Europe*; J von Radowitz, "Scientific Study Reveals Why 'Love Hurts'" (11 October 2003) *The Irish Examiner.*

[3] S Connor, "How Dream of Reading Someone's Mind May Soon Become a Reality" (6 March 2008) *The Independent*.

[4] S Olson, "Brain Scans Raise Privacy Concerns" (2005) 307 *Science* 1548–1550; E Vul et al, "Puzzlingly High Correlations in fMRI Studies of Emotion, Personality, and Social Cognition" (2009) 4 *Perspectives on Psychological Science* 274–290.

[5] G Miller, "Don't Be Seduced by the Brain" (2008) 320 *Science* 1413.

[6] J Illes et al, "Neurotalk: Improving the Communication of Neuroscience Research" (2010) 11 *Nature Reviews Neuroscience* 61–69.

[7] J Illes, M Kirschen and J Gabrieli, "From Neuroimaging to Neuroethics" (2003) 6 *Nature Neuroscience* 205.

accepting submissions from all scientific disciplines, publication in these journals can be viewed as a rough metric of the perceived importance of a topic. In order to get published in these prestigious journals, both of which have high rejection rates, a manuscript must be deemed worthy by both the editorial team and members within the appropriate scientific community, as represented by peer reviewers. So, although hardly a definitive or generalisable statement of significance, publication in these journals provides one gauge of the current status and perceived weight of an area of scientific inquiry. The articles for this study were found by searching both *Science* and *Nature* (up until 15 June 2010). Two hundred and two research articles were found based on the use of fMRI. The earliest research articles published that used fMRI as a method were in 1994 in *Nature* and 1995 in *Science*.

We coded the content of each article into one or two categories using a modified version of Illes et al's taxonomy, [8] which included motor, sensory, basic cognition, higher order cognition, emotion, methods development, and non-human primate. In addition, we labeled some articles "physiological", which included articles that measure the brain's response to certain activities such as eating, and "mind-reading", which included research that involved detecting consciousness in patients or attempting to decipher and predict what someone is thinking.

We then looked at the newspaper articles that flowed from the science articles. A search in the Factiva database (http://www.factiva.com) yielded 1,955 newspaper articles (up until 15 June 2010) in English language newspapers worldwide that discussed the results of fMRI research. By searching for references to the journals *Science* or *Nature* within the newspaper articles, 182 newspaper articles were identified as being based on articles published in *Science* or *Nature*. The earliest of these appeared in 1995. Results from the Factiva search did not include duplicate articles from the same newspaper; but, since our intent was to measure overall interest, we did include duplicate articles published in different newspapers. We assessed each article and identified its topic and tone, using methods previously employed in relation to other areas of health technology.[9]

Finally, we collected and coded all review and commentary pieces relevant to the area of fMRI research published in *Science* and *Nature* (up until 15 June 2010), and found twenty review and commentary pieces in *Science* and eighteen in *Nature*. This was done in order to chart how the research community itself is reacting to neuroimaging research. The acceptance and publication of commentaries represents decisions by journal editors that serve as another – albeit quite modest – measure of the existing academic ethos.

3. Findings

Our results indicate that, in general, there has been increasing attention in both the popular press and in the peer reviewed literature to fMRI neuroimaging research. The

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[8] *Ibid.*

[9] T Bubela, H Boon and T Caulfield, "Herbal Remedy Clinical Trials in the Media: A Comparison with the Coverage of Conventional Pharmaceuticals" (2008) 6 *BMC Medicine* 35–48; T Caulfield, T Bubela and C Murdoch, "Myriad and the Mass Media: The Covering of a Gene Patent Controversy" (2007) 9 *Genetics in Medicine* 850–855.

number of articles in *Science*, for example, has increased steadily since the first published article in 1995. *Nature*, however, seems to have been somewhat less enthusiastic about the area (Fig. 1), although interest has remained steady.[10] As with Illes et al,[11] we also found an increase in the number of studies published on higher order cognition in humans that involved social interaction and behaviour such as gambling and alcoholism (Fig. 2).

Fig. 1. Frequency of articles published each year between 1994 and 2009

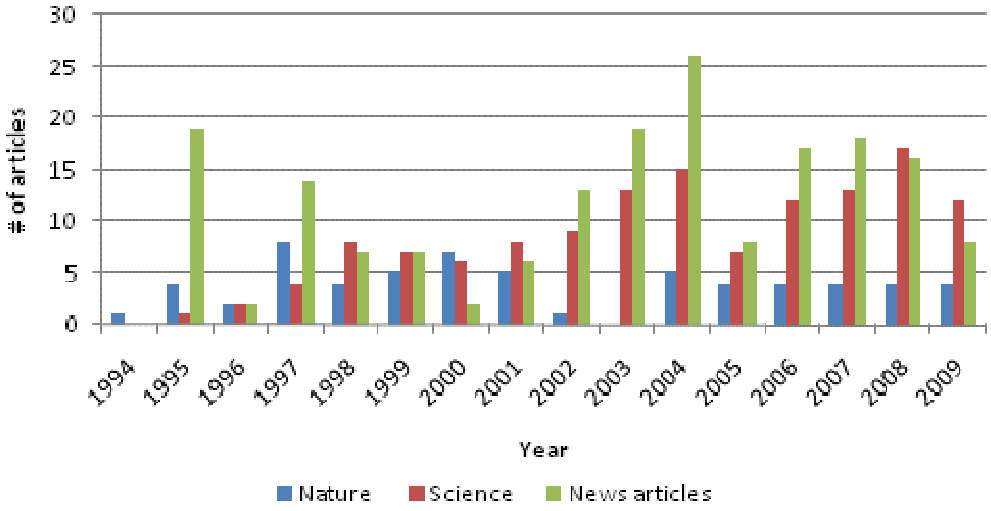
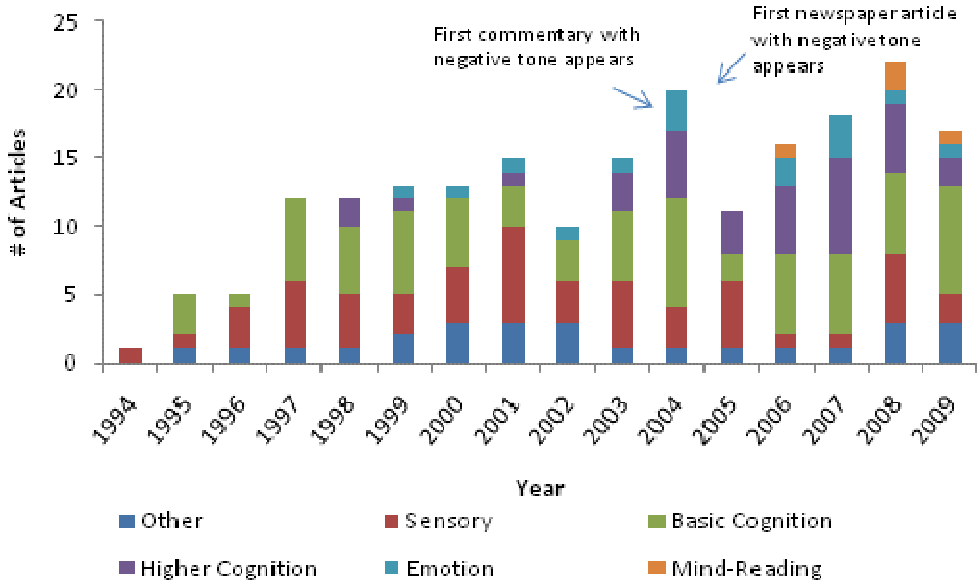


Fig. 2. Frequency and category of peer reviewed articles published each year between 1994 and 2009. "Other" includes articles about physiological and motor skills.

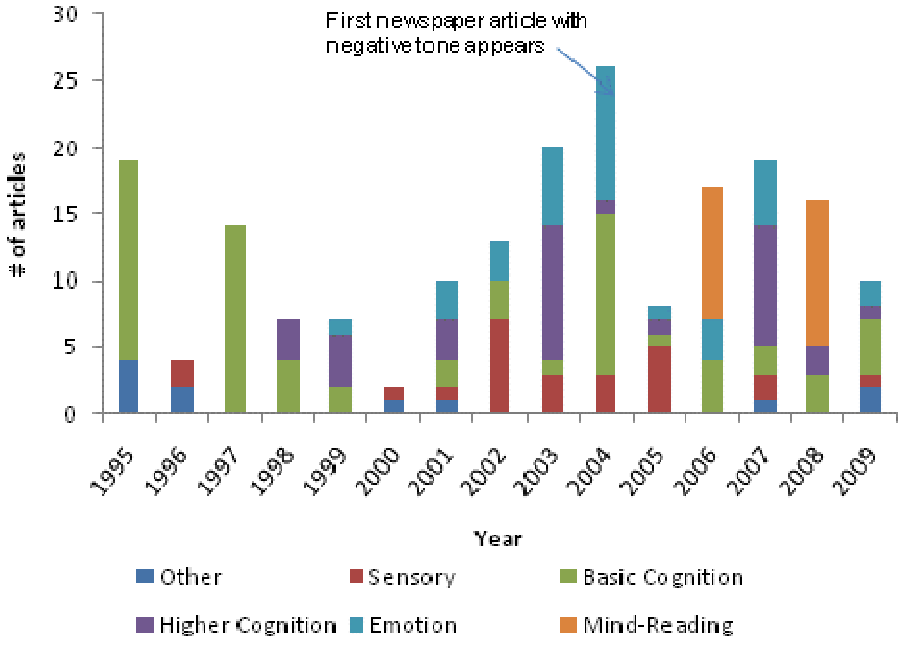
[10] In part, the more moderate publication rates in the journal *Nature* is undoubtedly due to the creation of the journal *Nature Neuroscience* (1998). But the fact that the journal *Nature*, the most prestigious of the *Nature* family journals, continues to publish fMRI work is, in itself, interesting and a measure of the level of interest in the field.

[11] See note 7 above.



While newspapers began publishing stories on fMRI research around the same time as *Nature* and *Science*, and after an initial burst of interest in 1995, the number of news articles began to increase steadily from 2000 (Fig. 3). The media has a clear preference for a particular type of neuroimaging study. While articles about higher order cognition accounted for less than 10% of the peer-reviewed articles in 1999, over 55% of the newspaper articles reported on higher order cognition. In 2004, when fMRI research coverage appeared to be at its highest, over 40% of articles were about higher order cognition and emotion. By 2006, mind-reading was the topic of over half of the newspaper articles, yet less than 10% of peer-reviewed research articles.

Fig. 3. Frequency and category of newspaper article published between 1995 and 2009. "Other" includes articles about physiological and motor skills.



One of the most striking findings is the clear shift in tone in the review articles and commentaries. Before 2002, these kind of academic articles portrayed neuroimaging in either a neutral or positive light. After 2002, these articles began to have a skeptical tenor – based on either social implications or methodological concerns. The majority (68.4%) of review articles and commentaries were also published after this date. It is interesting to note that after 2002, there is also a sharp increase in the number of research studies dealing with higher order cognition, emotion, and mind reading. The media interest in these topics (and in neuroimaging generally) also increased around that date. It is also interesting to note that the tone of newspaper articles was fairly evenly positive or neutral until 2004 when the first article with a negative tone appeared, following the first negative commentary published the previous year.

A number of review articles and commentaries addressed the ethical and legal issues that fMRI research raises. Increasing concern over the accuracy of fMRI scans to predict or determine human behaviour, especially in areas such as lie detection, has led some to question its usefulness and reliability.[12] An even bigger concern seems to be that fMRI creates privacy problems, or rather, that "the greatest threat to individual liberty may come not from the capacity of scanners to reveal hidden thoughts but from the mistaken belief that the results of brain scans are highly accurate".[13]

Interestingly, the types of studies that seem to generate the most criticism in the science literature are the same ones that receive the most media attention – that is, stories about higher cognition which have been highly critiqued in the scientific literature also received the most media coverage. For example, the controversial work by Owen et al which claimed that fMRI allowed the research team to detect awareness in a patient in a vegetative state and detect the patient imagining a game of tennis, received praise and criticism within both the scientific community and in the popular press.[14]

Our study has clear limitations. Though prestigious and influential, *Science* and *Nature* only provide a small window on the scientific community. There may be a more diverse range of studies found in journals that specifically focus on neurology. That said our findings about the trends in publishing – regarding both topic and frequency – fit well with the conclusions of other studies.[15] In addition, we only looked at media articles that related to *Science* or *Nature* journal articles, in order to examine the link between published academic articles in this area and representations of the research in the popular press.

4. Discussion

Despite these limitations, we believe our results provide a useful picture of the interest in and reaction to emerging neuroimaging research. There is a clear increase over time in the number of articles that focus on predicting and deciphering human thought and

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[12] J Knight, "The Truth about Lying" (2004) 428 *Nature* 692–694; H Pearson, "Lure of Lie Detectors Spooks Ethicists" (2006) 441 *Nature* 918–919.

[13] S Olson, see note 4 above.

[14] A Owen et al, "Detecting Awareness in the Vegetative State" (2006) 313 *Science* 1402.

[15] See e.g. note 7 above.

behaviour. There is also a clear shift in tone in the review and commentary pieces, indicating mounting skepticism in the scientific community itself about fMRI research, as well as growing interest in the social implications of this work. The more critical articles appear just as the more controversial work is emerging in the science literature and receiving attention in the popular press. This skepticism is also starting to appear in the popular press. It will be interesting to see if the emerging criticism will change the nature and number of studies published in the general scientific journals (i.e. will we see fewer and more conservative studies?) or in the tone of the press coverage. However, despite this growing skepticism, at the current time there still appears to be a strong media interest in this field.

In addition to these findings, our data informs other interesting issues about science publication issues more broadly. First, our analysis adds a modest bit of fuel to the controversial notion that more sensational studies – that is, studies that seem likely to generate media interest – may be more likely to get published in the most prestigious journals, but are also the studies that are most likely to have their credibility challenged.[16] In the context of neuroimaging this might be research that makes grand and generalisable claims about human behaviour. Given the recent scientific critiques of neuroimaging studies, including one that suggests that "[n]early half of the neuroimaging studies published in prestigious journals in 2008 contain unintentionally biased data that could distort their scientific conclusions"[17] (a commentary to Vul et al[18]), it is worth considering (and perhaps studying) the extent to which the publication agenda in the area of neuroimaging follows this pattern. Are publication decisions being determined by sensationalised portrayals of the work? If so, how will this trend impact the long term legitimacy of the field?

Second, our study highlights the connection between peer reviewed research papers and media reports, and their role in the generation of hype.[19] The topics that generated what seemed to be the most sensational news coverage flowed from specific journal articles. For example, Kay et al claimed they were able to discern which images participants had viewed based on fMRI scans.[20] Based on their results, they claimed that, "it may soon be possible to reconstruct a picture of a person's visual experience from measurements of brain activity alone".[21] Resulting newspaper article titles included, for example, "How Dreams of Reading Someone's Mind May Soon Become a Reality"[22] and "What's on Your Mind, Scientists Get a Glimpse".[23]

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[16] A Johnson, "Publish and Be Wrong" (9 October 2008) *The Economist*; N Young, J Ioannidis and O Al-Ubaydli, "Why Current Publication Practices May Distort Science" (2008) 5 *PLoS Medicine* 1418–1422.

[17] A Abbott, "Brain Imaging Skewed" (2009) 458 *Nature* 1087.

[18] E Vul et al, see note 4 above.

[19] T Bubela and T Caulfield, "Do the Print Media 'Hype' Genetic Research?: A Comparison of Newspaper Stories and Peer-Reviewed Research Papers" (2004) 170 *Canadian Medical Association Journal* 1399–1407.

[20] K Kay et al, "Identifying Natural Images from Human Brain Activity" (2008) 452 *Nature* 352–355.

[21] *Ibid,* 352.

[22] See note 3 above.

Given that media coverage of a study may increase citations,[24] we can see how a "sensationalisation cycle" can start:[25] the science journal publishes a potentially controversial study, this publication results in media coverage which, in turn, results in more attention to the study from both the public and the scientific community, thus promoting (and perhaps intensifying) the publication of potentially sensational studies. At some point however, the scientific community may react negatively if it views emerging work as being inappropriately hyped or methodologically flawed. A correction occurs, and more critical commentary begins to appear. This is the classic "hype curve" pattern of representation, often associated with new science and emerging technologies.[26] Our study hints that this pattern may be starting to emerge in the context of neuroimaging.

Of course, it is not uncommon for an area of research to be sensationalised.[27] Indeed, the realms of genetics and stem cell research may be two familiar examples of similar trends. Such enthusiasm is both understandable and expected in light of the significant scientific possibilities these fields of research, including neuroimaging, hold. To some degree, this is a normal part of the innovation process.[28] Enthusiasm attracts funds and creates momentum. Unfortunately, there are significant potential downsides to a pattern of sensationalised coverage, including the risk of losing the public's trust and attention if the promised claims are not verified. This risk may be particularly acute in the field of neuroimaging, given the powerful impact neuroimaging appears to have on public perceptions of the value and meaning of research.[29] As Check noted, "the public often accepts research findings long before the investigators themselves feel they really understand what the results mean".[30] In order to encourage continued support for neuroimaging research, the scientific community should remain sensitive to the nature and potential impact of the scientific and media coverage of the field.

Acknowledgements

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[23] R Ingham, "What's On Your Mind? Scientists Get a Glimpse" (6 March 2008) *Montreal Gazette*.

[24] V Kiernan, "Diffusion of News about Research" (2003) 25 *Science Communication* 3–13.

[25] T Caulfield, "Popular Media, Biotechnology, and the Cycle of Hype" (2005) 5 *Houston Journal of Health Law and Policy* 213–233.

[26] C Mason and E Manzotti, "Induced Pluripotent Stem Cells: An Emerging Technology Platform and the Gartner Hype Cycle" (2009) 4 *Regenerative Medicine* 329–331.

[27] G Lewison et al, "How Do the Media Report Cancer Research?" (2008) 99 *British Journal of Cancer* 569–576; A Petersen, "The Ethics of Expectations: Biobanks and the Promise of Personalised Medicine" (2009) 28 *Monash Bioethics Review* 5.1–5.12.

[28] J Kimmelman, *Gene Transfer and the Ethics of First-in-Human Experiments: Lost in Translation*. (New York: CUP, 2009).

[29] E Check, "Ethicists Urge Caution Over Emotive Power of Brain Scans" (2005) 435 *Nature* 254–255.

[30] *Ibid*, 255.